VEGETATION

4

Introduction

Vegetation Overview

- Vegetation in Yellowstone is typical of the Rocky Mountains.
- Elements of the Great Plains and Great Basin floras mix with Rocky Mountain vegetation in the vicinity of Gardiner and Stephen's Creek.
- The interaction of climate and geologic substrate controls distribution of vegetation in the park.
- Disturbances—fire, floods, insects, disease—occur periodically, affecting portions of the park.
- Hydrothermal areas support unique plant communities and rare species.
- Lodgepole pine alone comprises 80% of the forest canopy.
- Six other conifer tree species: whitebark pine, Englemann spruce, subalpine fir, Douglas-fir, Rocky Mountain juniper, limber pine.
- Deciduous trees include quaking aspen and several species of cottonwood.
- Shrubs include common juniper, sagebrush (many species), Rocky Mountain maple.
- Wildflowers number in the hundreds.
- Two endemics—Ross' bentgrass and Yellowstone sand verbena.
- More than 199 exotics, including Timothy grass and Dalmation toadflax.

Management

- Controlling exotics, which threaten native species, prevalent in developed areas; some are spreading into the backcountry.
- Surveying areas for sensitive or rare vegetation before disturbance such as constructing a new facility.

Situated on the Continental Divide in the central Rocky Mountains, Yellowstone's vegetation is composed primarily of typical Rocky Mountain species. The flora is also influenced both by the Great Plains to the east and the Intermountain flora to the west. The exact plant community present in any area of the park reflects a complex interaction between many factors including the regional flora, the climate, the topography, and the local substrates/soils.

The vegetation of the park is interrelated with the geology of the park *(see Chapter 2).* The region's caldera explosions catastrophically destroyed vegetation. In addition, glaciers significantly altered the region during the ice ages. Today, the roughly 1100 native species of flowering plants that occur in the park represent the species able to either persist in the area or recolonize after glaciers, lava flows, and other major disturbances. Unlike southwestern Wyoming or central Idaho, the Greater Yellowstone region has few endemic vascular plant species, primarily in the eastern portion of the Absaroka Mountains outside of Yellowstone Park.

Within Yellowstone, only two endemics occur, Yellowstone sand verbena *(Abronia ammophila)* and Ross' bent grass *(Agrostis rossiae)* *(see page 58).*

Major Types

Montane Forests

Yellowstone is clothed in forests, covering roughly 80 percent of the park. Miles and miles of lodgepole pine forest characterize the park, especially within the confines of the Yellowstone caldera. Also present in the park are extensive areas of forest dominated by subalpine fir and Engelmann spruce, especially in areas underlain by andesites such as the Absaroka Range. These species can also be common in the understory where the canopy is entirely composed of lodgepole pine. Through time, in the absence of fire, the subalpine fir and Engelmann spruce will replace the lodgepole pine, leading to a canopy dominated by these species. At higher elevations such as the Absaroka Mountains and the Washburn Range, whitebark pine becomes a significant component of the forest. In the upper subalpine zone, whitebark pine, Engelmann spruce, and subalpine fir often grow in small areas separated by subalpine meadows. Severe conditions near treeline—wind and dessication—cause distorted forms known as krumholtz where most of the 'tree' is protected below the winter snow.

Douglas-fir Forests

Douglas-fir forests occur at lower elevations, especially in the northern portion of the park. The thick bark of Douglas-fir trees allows them to tolerate low intensity fire. Some of the trees in these forests are several hundred years old and show fire scars from a succession of low intensity ground fires. In contrast, lodgepole pine trees have very thin bark and can be killed by ground fires

Understory Vegetation

The understory vegetation differs according to precipitation regime, the forest type, and the substrate. Lodgepole pine forest is often characterized by a very sparse understory composed mostly of elk sedge *(Carex geyeri)*, or grouse whortleberry *(Vaccinium scoparium).* Pinegrass *(Calamagrostis rubescens)* occurs frequently under Douglas-fir forest but is also common under other forest types, especially where the soil is better developed or moister. In some areas of the park such as Bechler and around the edges of the Northern Range, a more obviously developed shrub layer is composed of species such as Utah honeysuckle *(Lonicera utahensis)*, snowberry *(Symphoricarpos sp.)* and buffaloberry *(Shepherdia canadensis).*

Sagebrush-Steppe

The Northern Range is composed of extensive stretches of sagebrush-steppe. Mountain big sagebrush *(Artemisia tridentata var. vaseyana)* dominates this community type, along with several other species and varieties of sagebrush. Several grass species, such as Idaho fescue *(Festuca idahoensis),* also dominate sagebrush-steppe. The Northern Range can be spectacular with wildflowers in late June and early July. Sagebrush-steppe also occurs in Hayden Valley, Pelican Valley, and Gardner's Hole.

Wildflowers

Wildflowers such as lupines and arnicas often grow under the forest canopy, but the most conspicuous wildflower displays occur in the open meadows and sagebrush-steppe. The appearance of spring beauties, glacier lilies, and steer's head announce spring in the park. Soon colors splash the slopes, especially on the Northern Range—yellow from arrowleaf balsamroot, white from phlox, reds and oranges from paintbrush, and blue from penstemon and lupine. Goldenrod and gentians indicate the coming of autumn.

Wetlands and Riparian Areas

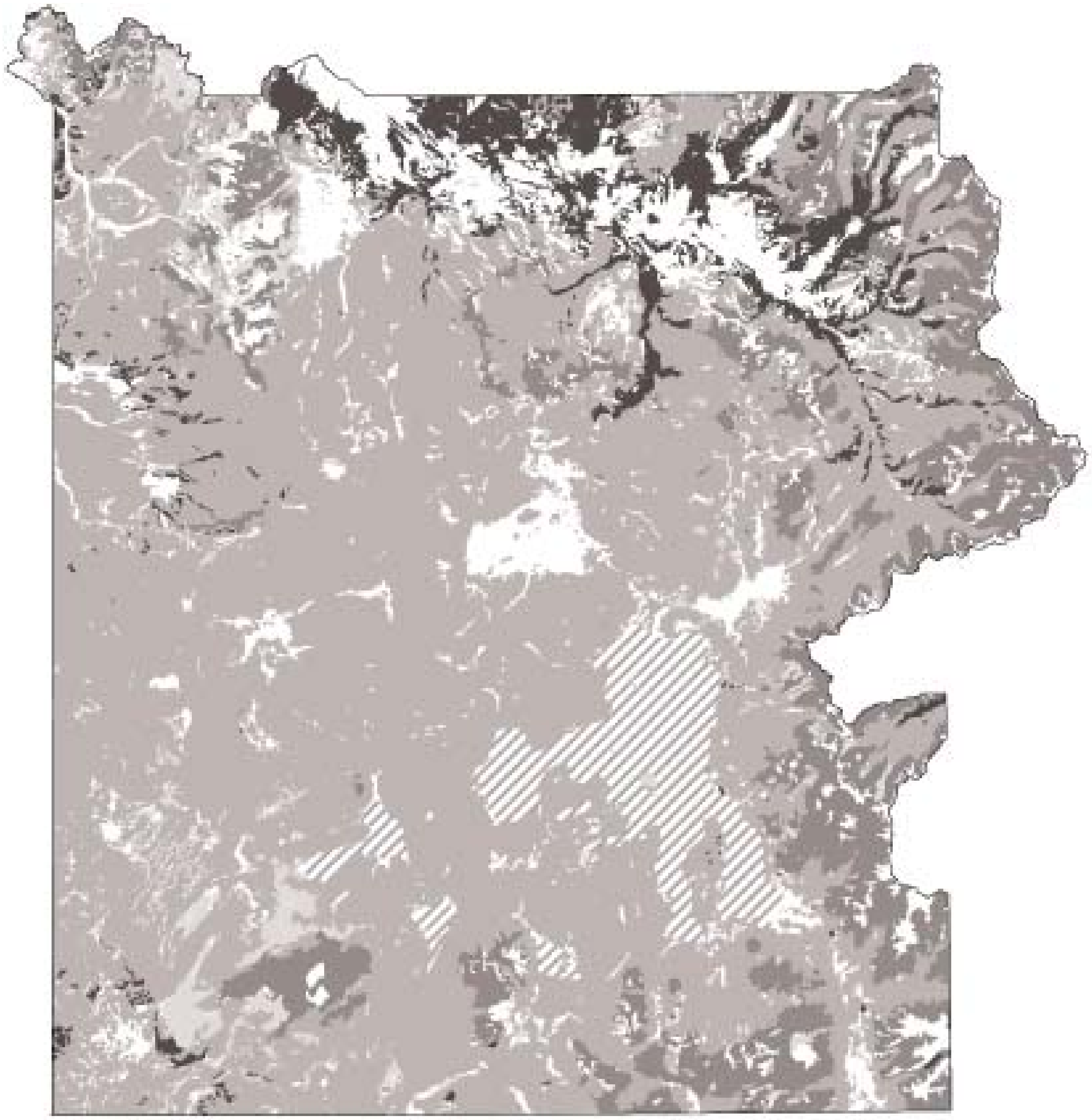
Even though the park is dominated by forest and sagebrush-steppe, many other community types occur within the boundaries. Wetlands are a conspicuous component in the area, with extensive areas of sedge bottoms and willow thickets. Subalpine meadows are rich in the number of different species of wildflowers and merge into alpine tundra on the highest peaks. Rivers, lakes, and ponds support aquatic vegetation in addition to the obvious inhabitants such as fish.

Hydrothermal Communities

Yellowstone is the best place in the world to see hydrothermal phenomenon such as geysers, hot springs, and fumaroles. Fascinating and unique plant communities have developed in the expanses of thermally heated ground. Many of the species that occur in the geyser basins are actually species that tolerate tremendously different conditions, and thus grow all over the western United States. Other species, though, are typical of the central Rockies, or are regional endemics.

Effects of Disturbances

The vegetation clothing the park appears at first glance to be static and unchanging, but must, in fact, respond to change. Hydrothermal plant communities demonstrate in very short periods of time that change is fundamental in any natural system. In a few days, the ground can heat up, perhaps triggered by an earthquake, and fry plants, while an adjacent area may be turning cooler, allowing plants to invade a previously inhospitable place. The vegetation of the park today reflects the effects of many different types of natural disturbance such as forest fire *(see Chapter 5)*, floods, landslides, insect infestations, blowdowns, and the continually changing climate.



Lodgepole pine forests
- More than 80% of the total park forested area dominated by lodgepole pine.
- Can be seral (developing) or climax.
- Climax forests underlain by rhyolite.

Douglas-fir forests
- Lower elevations (<7600 ft.) associated with the Lamar, Yellowstone, and Madison river drainages.
- Often less than 20 inches of annual precipitation.
- More frequent historic fire interval (25–60 year) than other forest types in the park.

Spruce-fir forests
- Engelmann spruce and subalpine fir dominate older forests.
- Usually found on moist and/or fertile substrates.
- Climax forests underlain by andesitic soils.

Whitebark pine forests
- Major overstory component at elevations above 8400 feet.
- Major understory component of lodgepole-dominated forests from 7,000 to 8,000 ft in elevation.
- Seeds are ecologically important food for a variety of wildlife species.

Non-forest
- Includes grasslands, sagebrush, alpine meadows, talus, and hydrothermal environments.
- Encompasses the moisture spectrum from dry sagebrush shrublands to wet alpine meadows.
- Provides the winter and summer forage base for ungulates.

Other types not shown on map
- Aspen—found in small clones interspersed among the sagebrush/forest ecotone (transition zone) along the Yellowstone, Madison, and Snake river drainages.
- Wetland—includes various grass, forb, rush, and sedge species.
- Riparian—typically streamside vegetation includes cottonwoods, willows, and various deciduous shrubs.

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Vegetation: Trees

Major Types of Trees

Lodgepole pine *Pinus contorta*
- Most common tree in park
- Needles in groups of twos
- May have serotinous cones
- Up to 75 feet tall

Limber pine *P. flexilus*
- Needles in groups of five
- Young branches are flexible
- Up to 75 feet tall
- Often on calcium-rich soil

Whitebark pine *P. albicaulis*
- Grows at higher elevations, above 7000 feet
- Needles in groups of five
- Purple-brown cones produce important food for squirrels, bears, Clark's nutcrackers
- Up to 75 feet tall

Englemann spruce *Picea engelmannii*
- Often along creeks, or wet areas
- Sharp, square needles grow singly
- Cones hang down and remain intact, with no bract between scales
- Up to 100 feet tall

Subalpine fir *Abies lasiocarpa*
- Only true fir in the park
- Blunt, flat needles
- Cones grow upright, disintegrate on tree
- Up to 100 feet tall

Douglas-fir *Pseudotsuga menziesii*
- Resembles the fir and the hemlock, hence its generic name Pseudotsuga, which means "false hemlock"
- Cones hang down and remain intact, with 3-pronged bract between scales
- Thick bark resists fires
- Up to 100 feet tall

Rocky Mountain juniper
Juniperus scopulorum
- Needles scale-like
- Cones are small and fleshy
- Up to 30 feet tall

Cottonwood *Populus spp.*
- Several species and hybrids
- Up to 75 feet tall
- Thick, furrowed bark
- Seeds with tangled hairs—the "cotton"— dispersed by wind

Quaking aspen *Populus tremuloides*
- Sedimentary soils in damp areas
- Flexible stems quake and shiver in the breeze
- Trunks often rough and black due to browsing by elk and other animals
- Reproduces by cloning (most often), and by seeds (related to fire)

LODGEPOLE PINE

The lodgepole pine *(Pinus contorta)* is by far the most common tree in Yellowstone. Early botanical explorers first encountered the species along the west coast where it is often contorted into a twisted tree by the wind, and thus named it *Pinus contorta var. contorta.* The Rocky Mountain variety, which grows very straight, is *Pinus contorta var. latifolia.* Various Native American tribes used this tree to make the frames of their tipis or lodges, hence the name "lodgepole" pine. Typically, lodgepole pine in Yellowstone is seldom more than 75 feet tall. The species is shade intolerant; any branches left in the shade below the canopy will wither and fall off the tree. Lodgepoles growing by themselves will often have branches all the way to the base of the trunk because sunlight can reach the whole tree.

Lodgepoles are the only pine in Yellowstone whose needles grow in groups of two. The bark is typically somewhat brown to yellowish, but a grayish-black fungus often grows on the shady parts of the bark, giving the tree a dark cast.

Like all conifers, lodgepole pines have both male and female cones. The male cones produce huge quantities of yellow pollen in June and July. This yellow pollen is often seen in pools of rainwater around the park or at the edges of lakes and ponds. The lodgepole's female cone takes two years to mature. In the first summer, the cones look like tiny, ruby-red miniature cones out near the end of the branches. The next year, after fertilization, the cone starts rapidly growing and soon becomes a conspicuous green. The female cones either open at maturity releasing the seeds, or remain closed—a condition called serotiny—until subjected to high heat such as a forest fire. These cones remain closed and hanging on the tree for years until the right conditions allow them to open. Within a short period of time after the tree flashes into flame, the cones open up and release seeds over the blackened area, effectively dispersing seeds after forest fires. Trees without serotinous cones (like Engelmann spruce, subalpine fir, and Douglas-fir) must rely on wind, animals, or other agents to carry seeds into recently burned areas.

Lodgepole pines prefer a sightly acid soil, and will grow quickly in mineral soils disturbed by fire or by humans (such as a road cut). Their roots spread out sideways and do not extend deeply—an advantage in Yellowstone where the soil is only about 6 to 12 inches deep, but a disadvantage in high winds. Lodgepole pines are vulnerable in windstorms, especially individuals that are isolated or in the open.

Besides reseeding effectively after disturbance, lodgepole pines can grow in conditions ranging from very wet ground to very poor soil prevalent within the Yellowstone caldera. This flexibility allows the species to occur in habitat that otherwise would not be forested.

Because lodgepole pines are dependent on sunny situations for seedling establishment and survival, the trees do not reproduce well until the canopy opens up significantly. In the Yellowstone region, this allows the lodgepole pine forest to be replaced by shade-loving seedlings of subalpine fir and Engelmann spruce where the soil is well-developed enough to support either of these species. In areas of nutrient poor soil, where Engelmann spruce and subalpine fir struggle, lodgepole pines will eventually be replaced by more lodgepole pine trees as the forest finally opens enough to allow young lodgepoles to become established.

Only Here

- Yellowstone is home to two endemic species—plants that grow nowhere else—Ross's bentgrass and Yellowstone sand verbena.
- Endemics often occur in unusual or specialized habitats such as thermal areas.
- Several other species are unique to the Greater Yellowstone Area: warm springs spike rush, which grows in warm water; and Tweedy's rush, sometimes the only vascular plant growing in acidic thermal areas.

Ross's bentgrass *(Agrostis rossiae)*

Ross's bentgrass (shown above) only occurs on thermal ground along the Firehole River and near Shoshone Lake. This species seems to require locations providing the right combination of moisture and warmth that create a natural greenhouse. The temperature within an inch of the surface under a patch of this grass is usually roughly 100ºF. As a result, this grass is one of the first species to green up in warm nooks and crannies of geyserite—sometimes as early as January. Inflorescences (flowers) may be present in February and March, but typically the plants do not produce viable seed that early. Full bloom occurs in late May and early June. As soon as temperatures rise in the early summer, the plants dry out due to the summer sun above and the thermal heat beneath. Ross's bentgrass is already dead and hard to find by July when most of the park's wildflowers are in full bloom.

Closely related species of grass also occur in the geyser basins. Tickle grass *(A. scabra)* is common all through the interior of the park. This species is much more frequently encountered in the geyser basins than Ross's bentgrass and looks similar. Ross's bentgrass is shorter, rarely growing taller than six inches and more typically only 2–3 inches. Another diagnostic characteristic of Ross's bentgrass is that the inflorescence never completely opens up.

Any plant growing in thermal areas must be able to deal with constant change. A successful plant in the geyser basins must be able to shift location relatively easily as one major thermal change or several changes could eradicate the entire population. Apparently, Ross's bentgrass deals with this problem efficiently. Its seed dispersal mechanism has not been studied, but probably includes traveling on the muddy hooves of bison and elk who inhabit thermal areas during the winter. Exotic species pose the only known threat; as they spread in thermal areas, they eventually may outcompete Ross's bentgrass.

Yellowstone Sand Verbena *(Abronia ammophila)*

Yellowstone sand verbena occurs along the shore of Yellowstone Lake. Taxonomists debate about the relationship of this population of sand verbena to other sand verbenas. Recent work suggests that Yellowstone sand verbena is distinct at least at the subspecific level, and is certainly reproductively isolated from the closest sand verbena populations in the Bighorn Basin of Wyoming.

Sand verbenas are a member of the four o'clock family, which is primarily a tropical family of flowering plants. Very few members of the family grow this far north. Little is known about the life history of Yellowstone sand verbena. It was described as an annual in the only monograph that has examined this genus in recent years, but it is a perennial. It grows close to the sand surface. Some individuals occur near warm ground, so the thermal activity in Yellowstone may be helping the survival of this species. The flowers are white and the foliage is sticky. Apparently, the sand verbena flowers from roughly mid June until killing frosts in early September.

The full extent and impact of exotic plants in Yellowstone is unknown. Many grow in disturbed areas such as developments, road corridors, and thermal basins; they also are spreading into the backcountry. Several exotics, such as the common dandelion, have spread throughout the park.

Exotic plants can displace native plant species and change the nature of vegetation communities. These changes can profoundly effect the entire ecosystem. For example, exotics unpalatable to wildlife may replace preferred native plants, leading to changes in grazing activity. In turn, this stresses plants not adapted to grazing.

Controlling all the exotic species, some well-established, is unrealistic. The park prioritizes them into several categories, thereby focusing control action on species posing the most serious threat or are most likely to be controlled.

The park uses Integrated Pest Management—chemical, biological, sociological, and mechanical methods—to control some of the exotic plants. The park also cooperates with adjacent state and county Weed Control Boards to share knowledge and technology related to exotic plant detection and control.

Exotic Species

- 199 exotic plant species in park
- Resource managers target the most threatening species for control or removal.
- Species include:
  Dalmation toadflax
  Spotted knapweed
  Canada thistle
  Ox-eye daisy
  Houndstongue
  Leafy spurge

Dalmation toadflax *Linaria dalmatica*

- Northern portions of the park, especially around Mammoth.
- Highly invasive, replacing native plants.
- Intense biological and chemical control efforts during the late 1960s and early 1970s were unsuccessful.

Spotted knapweed *Centaurea maculosa*

- Along roadsides and in the vicinity of Mammoth.
- Aggressive species that, once established, forms a monoculture, which could displace native grasses on the ungulate winter and summer ranges.
- Aggressive control efforts underway to prevent a catastrophic change in park vegetation.

Canada thistle *Cirsium arvense*

- Throughout the park and adjacent national forests.
- Airborne seed enable it to spread widely throughout the park, invading wetlands.
- Forms dense monocultures, thus radically changing vegetation.

Ox-eye daisy *Leucanthemum vulgare*

- Mammoth and Madison areas, where it may have been planted in flower gardens.
- Can become dominant in meadows, is unpalatable to elk and other wildlife.
- Control efforts have substantially curtailed infestation; monitoring and evaluation continue.

Houndstongue *Cynoglossum officinale*

- Primarily Mammoth and East Entrance.
- May have been introduced by contaminated hay used by both the National Park Service and concessioners in their horse operations.
- Highly invasive, replacing native plants.
- Seeds easily attach to the coats of animals, and thus spread along animal corridors.

Leafy spurge *Euphorbia esula*

- Small patches in Bechler and along roadsides, so far being successfully controlled but spreading actively in Paradise Valley north of the park and outside Bechler on the Targhee National Forest.
- Becomes a monoculture, forcing out native vegetation.
- Extremely hard to control because of deep roots (up to 30 feet) and dense vegetation.

Dalmatian toadflax

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Additional Information from Yellowstone National Park

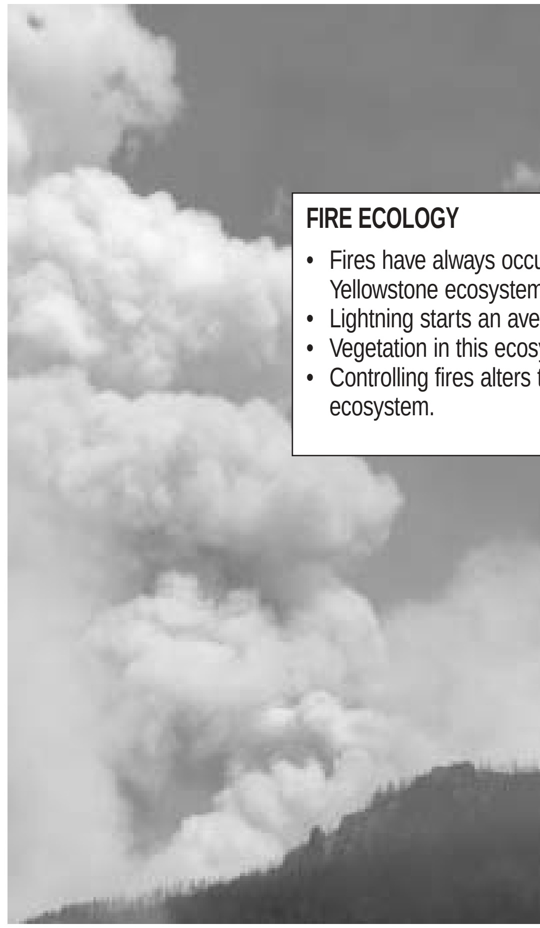
Yellowstone Science, published quarterly, reports on research and includes articles on natural and cultural resources. Free; available from the Yellowstone Center for Resources, in the Yellowstone Research Library, or online at www.nps.gov/yell.

Yellowstone Today, published seasonally and distributed at entrance gates and visitor centers, includes features on park resources such as hydrothermal features.

Site Bulletins, published as needed, provide more detailed information on park topics such as bison management, lake trout, grizzly bears, and wolves. Free; available upon request from visitor centers.

Yellowstone National Park website, www.nps.gov/yell, includes an array of park information about resources, science, recreation, and issues.

FIRE IN YELLOWSTONE



FIRE ECOLOGY

- Fires have always occurred periodically in the Yellowstone ecosystem.
- Lightning starts an average of 22 fires annually.
- Vegetation in this ecosystem is adapted to fire.
- Controlling fires alters the dynamics of the ecosystem.

Fire is a natural force operating in the Yellowstone ecosystem since the beginning of time. Fire scars on old Douglas-fir trees in the Lamar River valley indicate an average frequency of one fire every 25 to 60 years. Even-aged stands of lodgepole pine throughout the park and charcoal in the soil indicate fire intervals of 200 years or more in these forests. Records kept since 1931 show that lightning starts an average of 22 fires each year.

The vegetation in the Greater Yellowstone Ecosystem has adapted to fire and in some cases is dependent on it. Some plant communities depend on the removal of the forest overstory to become established; they are the first to inhabit sites after a fire. Other plants growing on the forest floor are adapted to survive at a subsistence level for long periods of time until fires open the overstory.

Fire can limit trees in grasslands. Microhabitats suitable for tree seedling establishment are rare in a grassland, but if a seed reaches such a microhabitat during a favorable year, a tree may grow. Once the tree is growing, it begins to influence the immediate environment. More tree habitat is created and a small forest island eventually appears. Periodic fire kills the small trees before they have a chance to become islands, thus maintaining the grassland.

Older Douglas-fir trees are adapted to fire by having thick bark that resists damage by ground fires. In the past, in areas like the park's Northern Range, frequent ground fire kept most young Douglas-fir trees from becoming part of the overstory. The widely scattered, large, fire-scarred trees in some of the dense Douglas-fir stands in the valleys of the Lamar and Gardner rivers are probably remnants of these communities.

Lodgepole pines produce two types of cones, one of which opens after being heated to at least 113ºF. These fire-dependent cones—called serotinous—ensure seedling establishment after a fire. Lodgepole seedlings also need an open canopy that allows plenty of sun through. This happens only if mature trees in a lodgepole stand are periodically thinned by disease, fire, or other natural agents. Such disturbances create a landscape more diverse in age, which reduces the probability of disease or fire spreading through large areas.

Fire influences the rate that minerals become available to plants by rapidly releasing these nutrients from wood and forest litter. Fire's heat may also hasten the weathering and release of soil minerals. Following a fire, plants rapidly absorb this abundant supply of soluble minerals.

Fire control alters these natural conditions. Landscape diversity diminishes, forest size increases, and plant community structure and composition change. Species susceptible to fires become prominent; diseases spread over

Effects of Fire Control

- *Landscape becomes primarily older communities, decreasing diversity.*
- *Structure and composition of many communities favors species that do not benefit from fire.*
- *Insects and diseases are more likely to spread over larger areas.*
- *Litter and dead-fall continue to accumulate, increasing the chances of extreme fire behavior over larger areas.*

5

Fire Management

History

- For the first 100 years of the park's existence, managers believed that preservation of its resources meant that fires had to be extinguished.
- Scientific research revealed:

—fires have occurred in Yellowstone for as long as there has been vegetation to burn

—fire plays a role in creating the landscape

—fire is a part of the ecosystem that park managers want to preserve

—suppressing fires actually alters the natural landscape and diminishes diversity.

- 1972, Yellowstone began using natural fire management.
- Between 1972 and 1987, 234 fires burned nearly 35,000 acres—mostly in two dry years, 1979 and 1981.
- The fires of 1988 brought about management changes *(see next section).*

Current Fire Management Policy

The National Fire Plan, based on a report after the 2000 fire season, emphasizes interagency cooperation in fire management. Appropriations for the plan include $101 million for National Park Service projects and activities identified in plan.

greater areas; litter and deadfall accumulate; and minerals remain locked up or are more slowly released.

The expanses of even-aged lodgepole pine forests in Yellowstone are a good example of how fire—or lack of fire—affects this forest community.

Fire suppression began with the arrival of the U.S. Army, which was placed in charge of protecting the park in 1886. The Army, which was in Yellowstone until 1918, successfully extinguished some fires, though it is difficult to determine what effect their efforts had on overall fire frequency or extent of fires. During this period, fire suppression was most effective on the grasslands of the park's Northern Range. Throughout the rest of the park, which is largely covered by forest, reliable and consistent fire suppression began when modern airborne firefighting techniques became available after World War II.

On most public and private lands, maintaining wild processes is not as high a priority as other activities, and controlling wildfires may be appropriate. But in natural areas such as Yellowstone, preserving a state of wildness and its associated processes is a primary goal of management.

Evolution of Fire Management Plans

In 1972, Yellowstone was one of several national parks to initiate programs allowing some natural fires to run their courses. Two backcountry areas in the park (340,000 acres) were designated as locations where natural fires could burn.

In 1974, after the initial successes of the program, plans were made to expand the acreage and an environmental assessment (EA) was prepared in 1975. The EA recommended allowing fires to burn on about 1,700,000 acres in the park; it was approved early in 1976. Shortly thereafter Yellowstone National Park and the Bridger–Teton National Forest entered into a cooperative program allowing naturally caused fires in the Teton Wilderness to burn across the boundary between the two federal units.

Between 1972 (the first fire management plan) and 1988, Yellowstone's fire management plan was gradually revised and updated in accordance with National Park Service guidelines and as research provided new information:

- Tens of thousands of lightning strikes simply fizzled out with no acreage burned.
- 140 lightning-caused fires burned only a small area.
- More than 80 percent of the lightning starts went out by themselves.
- A total of 34,175 acres burned in the park as a result of natural fires.
- The largest natural fire burned about 7,400 acres. (Prior to this, the largest natural fire in the park's written history was in 1931 at Heart Lake where about 18,000 acres burned.)
- No human lives were lost, and no significant human injuries occurred due to fires.
- No park structures or special features were affected.

Based on these facts, a fire plan revision was begun in late 1986 and was in the final stages of approval by the spring of 1988. The plan's goals:

- To permit lightning-caused fires to burn under natural conditions.
- To prevent wildfire from destroying human life, property, historic and cultural sites, special natural features, or threatened and endangered species.
- To suppress all human-caused fires (and any natural fires whose suppression is deemed necessary) in as safe, cost-effective, and environmentally sensitive ways as possible.
- To resort to prescribed burning when and where necessary and practical to reduce hazardous fuels—primarily dead and down trees.

The plan was reviewed again after the fires of 1988 *(see next section)* when the Secretaries of the Departments of the Interior and Agriculture appointed a Fire Management Policy Review Team. Its final report, issued in May 1989, reaffirmed the basic soundness of natural fire policies in national parks and wilderness areas and offered 15 recommendations to improve federal fire management programs. These recommendations were incorporated into the National Park Service's Wildland Fire Management Policy Guideline revised in June 1990 and in the 1992 fire management plan revision in Yellowstone National Park.

National fire management plans continue to be reviewed after major fire seasons. For example, a major review of federal policies and programs followed the 1994 fire season when 34 people were killed in the western United States (none in Yellowstone, though). That review, completed in 1995, directs federal agencies to achieve a balance between suppression to protect life, property, and resources and "fire use" (the new term for natural fires that replaces prescribed natural fire) to regulate fuels and maintain healthy ecosystems. The report provides nine guiding principles and 13 policies to be incorporated into all wildland fire management actions. The principles include:

- Firefighter and public safety is the first priority.
- The role of wildland fire is an essential ecological process and a natural change agent and will be incorporated into the planning process. These principles and policies were incorporated into wildland fire management activities for the 1996–2002 fire seasons.

The National Fire Plan

During the 2000 fire season in the United States, almost 93,000 wildland fires burned close to 7.4 million acres and destroyed numerous structures. Subsequently, recommendations were developed on how to reduce the impacts of fire on rural communities and ensure sufficient firefighting resources for the future. That report, now known as the "National Fire Plan," identified five key points that continue to emphasize interagency approaches:

- *Firefighting: Continue to fight fires and be adequately prepared for the next year.*
- *Rehabilitation and Restoration: Restore landscapes and rebuild communities damaged by the wildfires of 2000.*
- *Hazardous Fuel Reduction: Invest in projects to reduce fire risk.*
- *Community Assistance: Work directly with communities to ensure adequate protection.*
- *Accountability: Be accountable and establish adequate oversight, coordination, program development, and monitoring for performance.*

The House and Senate approved an appropriations bill that included $101 million for National Park Service projects and activities identified in the National Fire Plan, including those in Yellowstone.

5

The Fires of 1988

Statistics

- 9 fires caused by humans.
- 42 fires caused by lightning.
- 36% (793,880 acres) of the park was affected, mostly by surface burns.
- Fires begun outside of the park burned 63% or approximately 500,000 acres of the total acreage.
- About 300 large mammals perished as a direct result of the fires: 246 elk, 9 bison, 4 mule deer, 2 moose.
- $120 million spent fighting the fires.
- 25,000 people employed in these efforts.

Fighting the Fires

- Until July 15, naturally-caused fires allowed to burn.
- After July 15, all fires were fought, regardless of their cause.
- Single largest fire-fighting effort in the history of the United States to date.
- Effort saved human life and property, but probably had little impact on the fires themselves.
- Rain and snow in September finally stopped the advance of the fires.

Results of the Fires

- Extensive review, some revision of fire management policy *(see previous section).*
- Extensive research on fire ecology *(see next section).*

Moisture Content

When the moisture content of vegetation is:

- *8 to 12%: lightning will start lots of fires & many will burn freely*
- *12 to 16%: some fires will burn up to 200 to 300 acres*
- *>16%: fires may start but few will burn any significant acreage*
- *24%: few fires start*

THE YEAR THE RAINS FAILED

Percent of Normal Rainfall Mammoth Hot Springs

	April	May	June	July	Aug.
1977	10	96	63	195	163
1978	91	126	42	99	46
1979	6	17	42	115	151
1980	33	152	55	143	199
1981	49	176	102	103	25
1982	169	74	89	118	163
1983	22	29	69	269	88
1984	44	84	66	297	121
1985	42	93	44	160	84
1986	145	47	64	212	75
1987	42	144	75	303	122
1988	155	181	20	79	10

The spring of 1988 was wet until June, when hardly any rain fell. Park managers and fire behavior specialists expected that July would be wet, though, as it had been historically *(see chart below left).* About 20 lightning-caused fires were allowed to burn after evaluation according to the fire management plan. Eleven of these fires burned themselves out, behaving just like many fires had in previous years.

Rains did not come in July as predicted. By late July, after almost two months of little rain, moisture content of grasses and small branches reached levels as low as 2 or 3 percent, downed trees were as low as 7 percent (kiln-dried lumber is 12 percent). A series of unusually high winds fanned flames that even in the dry conditions would not have moved with great speed.

Because of the extremely dry conditions, after July 15 no new natural fires were allowed to burn. (Exceptions were made for natural fires that started adjacent to existing fires, when the new fires were clearly going to burn into existing fires.) Even so, within a week the perimeter of the fires in the park doubled to about 17,000 acres. After July 21, all fires were subjected to full suppression efforts as staffing would allow. (Human-caused fires had been vigorously suppressed from the beginning.) On July 27, during a visit to Yellowstone, the Secretary of the Interior reaffirmed that the natural fire program had been suspended, and all fires would be fought.

Fighting the Fires

An extensive interagency fire suppression effort was initiated in mid July in the greater Yellowstone area in an attempt to control or contain the unprecedented series of wildfires. The extreme weather conditions and heavy, dry fuel accumulations presented even the most skilled professional firefighters with conditions rarely observed.

Accepted firefighting techniques were frequently ineffective because fires spread long distances by "spotting," a phenomenon in which wind carries embers from the tops of the 200-foot flames far out across unburned forest to start spot fires well ahead of the main fire. Regular spotting up to a mile and a half away from the fires made the widest bulldozer lines useless and enabled the fires to jump rivers, roads, and even the Grand Canyon of the Yellowstone River.

Fires often moved two miles per hour, with common daily advances of five to ten miles, consuming even very light fuels that would have been unburnable during an average season. The fast movement, coupled with spotting, made frontal attacks on the fires impossibly dangerous, as fire crews could easily be overrun or trapped between a main fire and its outlying spot fires. Even during the night, fires could not be fought. Normally, wildfires "lie down" at night as increased humidity and decreased temperature quiet them. But in 1988, the humidity remained low at night, and fire fighting was further complicated by extreme danger from falling trees.

Firefighting efforts were directed at controlling the flanks of fires and protecting lives and property in their paths. The fire experts on site generally agreed that only rain or snow could stop the fires. They were right: one-quarter inch of snow on September 11 stopped the advance of the fires.

By the last week in September, about 50 lightning-caused fires had occurred in or burned into the park, but only eight were still burning. More than $120,000,000 had been spent in control efforts on fires in the greater Yellowstone area, and most major park developments—and a few surrounding communities—had been evacuated at least once as fires approached within a few miles. The fire suppression efforts involved many different federal and state agencies, including the armed forces. At the height of the fires, ten thousand people were involved. This was the largest such cooperative effort ever undertaken in the United States.

Confusion in the Media

The Yellowstone area fires of 1988 received more national attention than any other event in the history of national parks. Unfortunately, many media reports were inaccurate or misleading and confused or alarmed the public. The reports tended to lump all fires in the Yellowstone area together as the "Yellowstone Park Fire"; they referred to these fires as part of the park's natural fire program, which was not true; and they often contained oversimplification of events and exaggeration of how many acres had burned. In Yellowstone National Park itself, the fires affected—but did not "devastate"—793,880 acres or 36 percent of the park's total acreage.

The North Fork Fire threatened Old Faithful, Madison, Canyon, Norris, West Yellowstone, Mammoth Hot Springs, and the Tower–Roosevelt area.

A number of major fires, most notably the North Fork Fire, the Hellroaring Fire, the Storm Creek Fire, the Huck Fire, and the Mink Fire started outside the park. These fires accounted for more than half of the total acres burned in the greater Yellowstone area, and included most of the ones that received intensive media attention. The North Fork Fire began in the Targhee National Forest and suppression attempts began immediately. The Storm Creek Fire started as a lightning strike in the Absaroka–Beartooth Wilderness of the Custer National Forest northeast of Yellowstone; it eventually threatened the Cooke City–Silver Gate area, where it received extended national television coverage.

Additional confusion resulted from the mistaken belief that managers in the Yellowstone area let park fires continue burning unchecked because of the natural fire plan—long after such fires were being fought. Confusion was probably heightened by misunderstandings about how fires are fought: if crews were observed letting a fire burn, casual observers might think the burn was merely being monitored. In fact, in many

Burned Area Within Yellowstone National Park

Burn Type	Acres	Percent of Park
• Crown fire: consuming the forest canopy, needles, and ground cover and debris	323,291	15%
• Mixed: mixture of burn types in areas where most of ground surface was burned	281,098	13%
• Meadows, sagebrush, grassland	51,301	2%
• Undifferentiated: variety of burn types	37,202	2%
• Undelineated: surface burns not detectable by satellite because under unburned canopy	100,988	4%
Total Burned Area	**793,880**	**36%**
Total Unburned Area	**1,427,920**	**64%**

Data from the Geographic Information Systems Laboratory, Yellowstone National Park, 1989; Table adapted from Yellowstone in the Afterglow: Lessons From the Fires, *Mary Ann Franke, 2000.*

instances, fire bosses recognized the hopelessness of stopping fires and concentrated their efforts on the protection of buildings and developed areas.

The most unfortunate public and media misconception about the Yellowstone firefighting effort may have been that human beings can always control fire. These fires could not be controlled; their raw, unbridled power cannot be overemphasized. Firefighters were compelled to choose their fights very carefully, and they deserve great praise for working so successfully to save all but a few of the buildings in the park.

Post-fire Response and Ecological Consequences

By late September, as the fires were diminishing, plans were underway in Yellowstone to develop comprehensive programs for all aspects of post-fire response. These included replacement, rehabilitation, or repair of damaged buildings, power lines, firelines, trails, campsites, and other facilities. Similarly, programs were developed to interpret the fires and their effects for visitors and for the general public. The park also cooperated with other agencies and state and local governments in promoting the economic recovery of communities near the park that were affected by the fires.

The same scene, in 1988 after the fires (left) and in 1989 (right)

Scientists wanted to monitor the ecological processes following these major fires. The National Park Service cooperated with other agencies and independent researchers and institutions in developing comprehensive research directions for this unparalleled scientific opportunity.

Observations began while the fires were still burning, when it was apparent that the fires did not annihilate all life forms in their paths. Burning at a variety of intensities, sometimes as ground fires, sometimes as crown fires, the fires killed many lodgepole pines and other trees, but did not kill most other plants; they merely burned the tops off of them, leaving roots to regenerate.

Temperatures high enough to kill seeds occurred in less than one-tenth of one percent of the park. Only under logs and in deep litter accumulations, where the fire was able to burn for several hours, did lethal heat penetrate more deeply into the soil. Where water was available, new plant growth began within a few days. In dry soils, the rhizomes, bulbs, root crown, seeds, and other reproductive tissues had to wait until soil moisture was replenished the following spring.

The fires of 1988 created a mosaic of burns, partial burns, and unburned areas that are now the new habitats of plants and animals. This mosaic actually provides natural firebreaks, reducing the number of fire starts and limiting fire size over time while sustaining a greater variety of plant and animal species. Vegetation capable of sustaining another major fire will be rare for decades, except in extraordinary situations.

Though animal movements were sometimes affected dramatically by the passage of fires, relatively few animals died. However, portions of the Northern Range burned, which affected winter survival of grazing animals when coupled with summer drought conditions. In this and many other ways, fires dramatically altered the habitat and food production of Yellowstone for the short term.

Yellowstone Fires 1988–2000

	Number of Fires		
Year	**Prescription**	**Suppressed**	**Acres Burned**
1988	*	45	793,880
1989	*	24	10
1990	*	43	247
1991	*	29	270
1992	15	14	485
1993	5	5	<1
1994	4	60	16,238
1995	9	7	<2
1996	13	11	3,261
1997	12	1	<1
1998	11	2	125
1999	11	4	10
2000	2	31	7,209
2001	16	21	7,987
2002	8	38	12,755

* After the natural fire policy was suspended on July 15, 1988, all fires in the park were suppressed until the revised policy was approved in 1992.

Table adapted from Yellowstone in the Afterglow: Lessons From the Fires, *Mary Ann Franke, 2000.*

5

Results of Fire Research Since 1988

What Has Changed

Although some long-term consequences of the fires remain to be seen, these changes have been caused entirely or in part by the fires of 1988:

- ✓ The replacement of thousands of acres of forest with standing or fallen snags and millions of lodgepole pine seedlings.
- ✓ The establishment of aspen seedlings in areas of the park where aspen had not previously existed.
- ✓ A decline in the moose population because of the loss of old growth forest.
- ✓ Shifts in stream channels as a result of debris flows from burned slopes.
- ✓ An increase in the public understanding and acceptance of the role of fire in wildland areas.
- ✓ A stronger program to reduce hazardous fuels around developed areas.

This list indicates the relatively small number of documented changes that might be apparent or of interest to the average park visitor.

What Has *NOT* Happened Since 1988

Whether you agree that Yellowstone became "a blighted wasteland for generations to come," as announced by one U.S. Senator in 1988, is a matter of personal opinion. But of the more quantifiable predictions that were made about the fires' long-term consequences, there is not yet any evidence that the following have come to pass:

- ✗ A long-term drop in park visitation.
- ✗ Flooding downstream of the park because of increased runoff on bare slopes.
- ✗ A decline in fish populations because increased erosion silts up the water.
- ✗ An increase in fish populations in smaller streams where deforestation and loss of shade could result in warmer water and higher nutrient levels.
- ✗ More rapid invasion of non-native plants into burned areas and corridors cleared as fire breaks.
- ✗ An increase in lynx following a boom in snowshoe hares as a result of changes in forest structure.
- ✗ Increased willow vigor and production of the defense compounds that deter its browsing by elk and moose.
- ✗ An increase in the elk population because of improved forage.
- ✗ A decline in the endangered grizzly bear population because of smaller whitebark pine seed crops.
- ✗ Another big fire season in Yellowstone because of all the fuel provided by so many dead and downed trees.
- ✗ Adoption of a program of prescribed burning to reduce the likelihood of future large fires in Yellowstone.

Soils

Fertile soils with good water-holding capacity that had a dense, diverse vegetation before the fire were likely to respond quickly after the fire with a variety of species and nearly complete cover. Some soils in Yellowstone supported little vegetation before the fires and have continued to have little since then. Areas that appear barren and highly erosive did not necessarily become that way because of fire.

Vegetation

As root systems of standing dead trees decay and lose their grip on the soil, the trees are gradually falling down, often with the help of a strong wind. However, many will remain upright for another decade or more.

Many of the forests that burned in 1988 were mature lodgepole stands, and this species is now recolonizing most burned areas. The first seedlings of Engelmann spruce, subalpine fir, and Douglas-fir are also beginning to emerge.

The density of lodgepole pine seedlings in burned areas after the 1988 fires varied, depending on factors such as fire severity, elevation, abundance of serotinous cones, and seedbed characteristics. Density ranged from 80 seedlings per hectare in a high-elevation stand with no serotinous cones to 1.9 million seedlings per hectare in a low-elevation stand in which nearly half the trees had serotinous cones. (One hectare is approximately 2.5 acres.)

About 28 percent of the park's whitebark pine forest burned in 1988. This affects grizzly bears, for which whitebark pine seeds are an important food in fall. Seeds not consumed by grizzlies remain in caches of red squirrels and Clark's nutcracker. These buried seeds and the hardiness of whitebark pine seedlings on exposed sites give this tree an initial advantage in large burned areas over conifers that depend on the wind to disperse their seeds. However, this slow-growing and long-lived tree is typically more than a century old before it begins producing cones. The young trees may die before reproducing if the interval between fires is too short or if faster-growing conifers overtake them. By 1995, whitebark pine seedlings had appeared in all 275 study plots, though density was not significantly different between burned and unburned sites.

About one-third of the aspen in the Northern Range burned in the 1988 fires—but the aspen stands were not destroyed. Fire that killed individual adult trees also enhanced aspen reproduction. Like other disturbances, fire stimulates the growth of suckers from the aspen's extensive underground root system. (Suckers and root shoots produce clones of the "parent" aspen.) Fire also leaves behind bare mineral soil devoid of taller plants—perfect conditions for aspen seedlings. After the fires of 1988, aspen seedlings appeared throughout the park's burned areas. All the young trees, whether clones or seedlings, can be heavily browsed by elk and may not grow much beyond shrub height. But the fires indirectly helped protect some of these young trees: the trunks of fallen trees keep elk from reaching some of the young aspen.

Like trees, most other types of vegetation in the park were not killed by the fires; the portion above ground may have been burned off, but the roots were left to regenerate. The regrowth of plant communities began as soon as the fire was gone and moisture was available, which in some sites was within days. In dry soils, the seeds had to wait until moisture was replenished the following spring. New seedlings grew even in the few areas where

Some grasses and flowers, such as fireweed (above), thrived only in the first years after the fires, while others such as pinegrass and showy aster have slowly but steadily increased.

Fifteen years after the fires, the moose is the only large mammal whose population appears to have declined because of the fires. Willow and subalpine fir—winter food for moose—were reduced by the fires. Dense forest canopies were also gone, so snow accumulated more deeply. The combination of less food and deeper snow contributed to increased winter moose mortality.

the soil had burned intensely enough to become sterilized. Within a few years, grasslands had largely returned to their pre-fire appearance, and sagebrush areas may be next, in another 20 to 30 years.

Plant growth was unusually lush in the first years after the fires because of the mineral nutrients in the ash and increased sunlight on the forest floor. Moss an inch or more thick became established in burned soils, and may have been a factor in moisture retention, promoting revegetation and slowing erosion.

Wildlife

Most ungulate (hoofed) species were more affected by the drought and the relatively severe winter that followed than by the fires themselves. Although none of their winter range burned, mule deer declined 19 percent and pronghorn 29 percent during the winter of 1988.

Elk mortality rose to about 40 percent in the winter of 1988–89, but scientists are unsure how much of this was due to reduced forage because of the fires. (At least 15 percent of the deaths were due to the hunting season outside the park.) Even without the fires, several factors would probably have led to high elk mortality that winter; summer drought, herd density, hunting harvest, and winter severity. The greatest impact of the fires would therefore be on the quantity and quality of forage available to elk in subsequent years. A two-year study following the fires found that the forage quality of three types of grasses was better at burned sites than unburned sites.

Of the 38 grizzly bears wearing radio transmitters when the fires began, 21 had home ranges that were hit by one or more of the fires: 13 of these bears moved into burned areas after the fire front had passed, three bears (adult females without young) stayed within active burns as the fire progressed, three bears remained outside the burn lines at all times, and two adult females could not be located (one of which was found in Hayden Valley in the summer of 1990). In a study from 1989–92, bears were found grazing more frequently at burned than unburned sites, especially on clover and fireweed. Even though bear feeding activity in some whitebark pine areas decreased as much as 63 percent, the fires have had no discernable impact on the number of grizzly bears in greater Yellowstone.

Rodents probably had the highest fire-related mortality of any mammals. Although many could escape the fires in burrows, others died of suffocation as the fires came through. They also were more exposed to predators because they had lost the cover of grasses and other plants. But if the number of small mammals did temporarily decline while their predators multiplied, the increased number of predators would soon face a food shortage themselves, continuing the ongoing adjustment in the predator-prey ratio.

Most birds were not directly harmed by the fires and some benefited. For example, raptors hunted rodents fleeing the fires. But osprey young that were still in their nests perished. Post-fire habitat changes helped some birds and not others. Cavity-nesting birds, such as Barrow's goldeneye, flickers, and bluebirds, had many dead trees for their nests. Robins and flickers found ants and worms more easily. Boreal owls, however, lost some of the mature forests they need.

Aquatic Resources

In general, the amount of soil loss and sediment deposits in streams varied greatly, but in most cases was within the normal range.

About a quarter of the Yellowstone Lake and Lewis Lake watersheds and half of the Heart Lake watershed burned to some extent, but no significant changes have been observed in nutrient enrichment, plankton production, or fish growth as a result. There was no apparent increase in streambank erosion or change in substrate composition or channel morphology that would affect cutthroat trout spawning habitat, nor does there appear to have been a decline in the number of spawning streams. No discernable fire-related effects have been observed in the fish populations or the angling experience in the six rivers that have been monitored regularly since 1988.

In other park watersheds, such as the Gibbon River, massive erosion and mudslides occurred during and after the heavy rains of the summer of 1989. However, by 1991, growth of plants had slowed this erosion.

Conclusion

In the years since the fires, visitors have marveled at the new vistas, the wildflower blooms, and the lush growth of new, young trees. Some visitors still feel that the Yellowstone they knew and loved is gone forever. But Yellowstone is not a museum—it is a functioning ecosystem in which fire plays a vital role.

Lodgepole seedling

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For More Information

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www.fire.nps.gov for information about the National Fire Plan

Additional Information from Yellowstone National Park

Yellowstone Science, published quarterly, reports on research and includes articles on natural and cultural resources. Free; available from the Yellowstone Center for Resources, in the Yellowstone Research Library, or online at www.nps.gov/yell.

Yellowstone Today, published seasonally and distributed at entrance gates and visitor centers, includes features on park resources such as hydrothermal features.

Yellowstone National Park website, www.nps.gov/yell, includes an array of park information about resources, science, recreation, and issues.